BTeV Electronics Projects

**Initial Requirements Documents
Proposed List & Schedule
&
Front-End High-Voltage System Mini-Workshops**

URLs To Requirements Documents
Definition (Issues) & Example/Template Files

- **Electronics Requirements Document Definition (Issues) File URL:**
  www-ese.fnal.gov/BTeV/ElectronicsProjects/Docs/Rqns/RqnsDocDefinition.doc

- **Example/Template Requirements File URL (Pixel High-Voltage):**
  www-ese.fnal.gov/BTeV/ElectronicsProjects/Docs/Rqns/RqnsDocTemplatePixelHV.doc

- (also via **BTeV internal web pages** then "**Electronics Projects**" then in the "**Document Definitions & Templates**" section)

Requirements Document - Example
Pixel High Voltage System

- Abstract
  - Short overview of the system being described.
    - Should give the reader a reasonable idea of the system and its function.

- Functional
  - This describes what the system is to do. For example:
    - Voltage range
    - Type of protection circuitry
    - Computer control and monitoring of each output

- Testing
  - How is the HV system to be tested?
    - This can be very difficult to describe but it is very important. Interaction with other devices has caused many problems in the past. Noise, multiple unit interaction, *etc.* need to be thought out carefully.

- System
  - How does this system fit into the overall BTeV system?
    - What is the communication hardware and protocol for control and monitoring?

Pixel High Voltage System - Example

- Software
  - How does this fit in the BTeV run control software?
    - What software needs to be supplied for the high-voltage power supply to work?
    - Control, maintenance, monitoring
- Packaging
  - Describe packaging constraints
    - Channels per unit
    - Modularity, mechanical standard package (if required)
- Power
  - What is the power source?
    - AC 1Φ, AC 3Φ, DC
    - Is a backup necessary?
- Cooling
  - Cooling requirements
    - Air
    - Fluid

Pixel High Voltage System - Example

- Electrical Noise
  - This is a place where many experiments have gotten into trouble
    - Conformance to FNAL specifications
    - Tolerance required to conducted and radiated noise
    - Generated noise by unit - limits
- Constraints
  - Any other constraints not covered elsewhere?
    - cable lengths
    - position (sideways, upside down)
- Reliability
  - What reliability standard does this unit have to meet?
    - 50,000 hrs MTBF?
    - Is MIL-HNBK-216F used to calculate?
- Maintenance
  - How is unit maintained?
    - Swap and fix on bench?
    - What is the MTTR? (this addresses pit access time)

Pixel High Voltage System - Example

- Safety
  - What FNAL and/or other safety documents must this system adhere to?
    - This is VERY important! Get ready for reviews.

- Training
  - Is special training required?
    - *e.g.,* High-voltage handling techniques

- Schedule, Budget & Personnel
  - This helps in the overall planning of the experiment schedule
    - When are prototypes required?
    - Production timeframe?
    - Cost & needed personnel?

- Quantities (Boards, ICs, Channels, Etc.)
  - This helps in the overall experiment costing
    - Prototype?
    - Production?
    - Spares?
    - Test stand?

Initial Requirements Documents
Proposed List & Schedule

Unless Requirements documents are thoroughly written then thoroughly reviewed by experts … and follow up discussions, updates and reviews are undertaken, these documents will be <u>useless</u>

The same holds true for Preliminary Specifications documents

Proposed Initial Requirements Documents

- ## Important:
  - System implementers know best when they are ready to start writing a Requirements document a particular project; please do <u>not</u> feel pressured to do so immediately
  - Once you have written a Requirements document, the need for one usually becomes apparent
  - Well-written & thoroughly-reviewed Requirements & Preliminary Specifications documents <u>will</u> save the BTeV experiment very substantial amounts of money and personnel time – and will minimize 'misunderstandings' between implementers

- **Custom Integrated Circuits**
  - **In development or soon-to-be-developed**
    - **Pixel IC & its interface to the readout electronics**
      - PPD/ESG, CD/ESE and BTeV personnel have agreed to start developing both the <u>Requirements & Preliminary Specifications documents</u> for the production pixel IC and its interface to other systems

      - It has been agreed that the next pixel IC prototype will conform to these requirements and preliminary specifications

      - This should substantially reduce the cost and personnel time incurred when multiple iterations of custom ICs are fabricated each requiring different readout methods and thus new test hardware and software

      - This IC will be fabricated in the 3rd or 4th quarter of 2001

      - All custom IC developments need to follow this same path

      - There should be plenty of time to write both documents and get them reviewed and approved without putting unreasonable demands on implementation schedules

- **Custom Integrated Circuits**
  - **In development or soon-to-be-developed**
    - **Strip IC**
      - How much of and how can the pixel IC development work be used in the development of the strip IC?
      - How practical is it to make the readout of the strip IC similar or even almost identical to that of the pixel IC (e.g., 212 MHz serial readout)?
      - Goal: Production version prototype by spring, 2002
    - **Straw TDC IC**
      - Can a programmable device with phased-locked loops (e.g., new Xilinx FPGA) be used rather than a custom IC?
      - If so, does this really save personnel time and money?
    - **RICH IC**
      - IDE has recently proposed an ASD and custom IC buffers with an FPGA for the digital interface to the BTeV system readout and control electronics
      - If this approach is the new baseline, a requirements document for the analog portion of the RICH front-end needs to be written

- **Custom Integrated Circuits**
  - **In development or soon-to-be-developed**
    - **EM Calorimeter QIE IC** and accompanying (or integrated) **flash ADC**
  - **Possibly available and not needing development**
    - **Muon ASD IC**
    - **Straw ASD IC**
    - Writing a requirements document and having it reviewed by experts is but one of the steps of insuring that the correct IC is chosen for these systems; testing is obviously another equally-important step
      - For example, is the ASDQ the correct IC for these systems?
      - If so, will the ASDQ be able to be fabricated at production time or will its technology be obsolete at foundries?
      - If not, one or two new ASD developments need to be initiated
    - **Note that the University of Pennsylvania is developing another ASD; we should try to have an impact on its requirements & specifications**

Custom Integrated Circuits
& Their Interfaces To The Readout Electronics
(continued)

- **Other Possible Custom Integrated Circuits**

  - **Pixel System:** (Possibly rad-hard) buffer ICs for driving pixel data from the outside of the vacuum vessel to a Pixel Data Combiner Board

  - **Pixel & Strip Systems:** A rad-hard Control/Monitoring & Timing IC
    - **May not be needed if new baseline conceptual designs prove to be workable**

- **Any others custom ICs required?**

Towards Front-End Preliminary Specifications
('fictitious' example of tabularized front-end requirements)

Sub-Detector =>	Silicon	RICH	Sub-Detector =>	Silicon	RICH
Channels	220K	140K	Noise level	< 1000e	<600e
Detector type	Silicon strip	Pad	Signal/noise	13	8
High voltage	200V	20KV+200V	Threshold	6000e	2000e
HV power	1KW	1.5KW	Noise occupancy	0.1%	1.0%
Meas. Type	Bin/amp	Bin/amp	Det. signal PW	< 25 nsec.	<25 nsec.
Avg. occupancy	0.5%	2.0%	PW after shaping	< 25 nsec.	<25 nsec.
Max. occupancy	1.0%	8.0%	Width ocp. factor	1	1
Det. efficiency	99%	90%	Total avg. ocp.	0.7%	3.0%
Det. Multiplicity	1.2	1.1	Total max. ocp.	1.3%	9.0%
Det. Sensitivity	12500e/Mips	5000e/Mips	Dynamic range	6-8 bits	6-8 bits
Min. signal	½ Mips	½ Mips	Resolution	4-6 bits	4-6 bits
Max. signal	10 Mips	10 Mips	Location of FE	On detector	On detector

Towards Front-End Preliminary Specifications
('fictitious' example continued)

Sub-Detector =>	Silicon	RICH	Sub-Detector =>	Silicon	RICH
Radiation level	300 Krads	Minimal	Link distance	0.6 meters	1.4 meters
Channels / IC	128	64	In trigger	Yes	No
No. of FE ICs	1738	2310	Etc.	Etc.	Etc.
FE type	> threshold	> threshold			
Power / FE IC	500 mw	350 mw			
Channels / FEB	512	192			
Power / FEB	4 W	2.4 W			
No. of FEBs	456	766			
Total FE power	2.4 KW	1.6 KW			
Data links total	456	766			
Ctrl. links total	456	766			
Mon. links total	456	766			

High-Voltage & Low-Voltage Power Supplies Needed Requirements Documents

- **All power supplies, high-voltage and low voltage**
  - **Magnetic fields:** Are there any special power supply requirements due to the detector magnets and their resulting magnetic fields?

- **High-voltage power supplies**
  - **Pixels:** Special attention must be given to requirements relating to operation very near the beam (e.g., electrical noise, its frequency components and resulting high-common mode rejection requirements up to very high frequencies)
  - **RICH**
  - **EM Calorimeter**
  - **Muons**
  - **Strips**
  - **Straws**

- **Low-voltage power supplies**
  - **Pixels:** (See above note on pixel high-voltage power supplies)

- **All high-voltage requirements documents & pixel low-voltage requirements documents**
  - Completed by mid-February, 2001 & reviewed by March 1, 2001

- **Initial custom ICs requirements documents**
  - Completed by mid-March, 2001 & reviewed March 31, 2001

- **Any others?**
  - Sensors?
  - Front-end (electronics) systems?
  - Data acquisition system?

- **Is this a reasonable schedule?**

Proposed Methodology & Schedule for

**Obtaining Baseline High-Voltage Power Supply Costs
(& Pixel Low-Voltage Power Supply Costs)**

for the February, 2002 Baseline Review

Proposed Methodology & Schedule

- **Early-March:** Reviewed Requirements documents given to prospective companies

- **Late-March:** One-day mini-workshops with companies
  - **CAEN**
    - **www.caen.de**
  - **ISEG**
    - **www.drivesoft.com**
    - **www.iseg.de**
  - **Any others?**
- **Late-April:** Initial quotes with preliminary specifications due from companies

- **Late-April Through Late May:** Quote reviews, comments, reworks, etc.

- **End-May:** Final quotes and preliminary specifications due from companies

Bottom Line

- **Don't be overwhelmed with the thought of writing Requirements & Preliminary Specifications documents; we are here to help you to make the task simpler**

- The most important thing is to get started

- Requirements documents:
  - Try not to write a specification
  - If you slip into specification mode, the reviewers will help you get out of that mode
  - Some things are gray - is it a specification or a requirement?
  - Use the template but modify it if necessary

- Better to have items in both documents rather than in neither

- Call us for help … anytime

Final Documents Comment

We are currently looking into available commercial software for managing technical projects including version control, requested change and change approval methodology, etc.

This software will be <u>web-based</u>